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Reduction in Renal Function After Renal Arteriography and After Renal Artery Angioplasty

S. Sabeti, M. Schillinger, W. Mlekusch, R. Ahmadi and E. Minar*

University of Vienna, Department of Angiology, Vienna General Hospital, Währinger Gürtel 18–20, A-1090 Vienna, Austria

Objective: *to investigate the incidence and risk factors for renal function deterioration after renal angiography and angioplasty or stenting.*
Methods: *a retrospective study of 85 consecutive patients undergoing selective renal artery arteriography (n = 53) or renal artery angioplasty % (PTRA) stenting (n = 32) for renal artery stenosis. Multivariate logistic regression analysis was used to determine independent predictors of deterioration of renal function, defined as an increase of serum creatinine by at least one third within 24 h.*
Results: *deterioration of renal function occurred in 13 patients (15%), [8/53 (15%) after angiography and 5/32 (16%) after PTRA/stenting]. Only pre-existing renal impairment (se-creatinine ≥ 177 μmol/l) (Odds ratio: 40; 95% confidence interval 1.2–72, p = 0.02) and administered dosage of contrast agent (more than 225 ml) (OR 67; 95% CI1 1.8–100, p = 0.02) were independently associated with renal function deterioration.*
Conclusion: *transient renal dysfunction after renal artery angiography or PTRA/stenting occurs in about 15% of patients, but persistent renal failure is uncommon. Pre-existing renal impairment and amount of contrast agent are independent risk factors. Endovascular treatment of renal artery stenosis is not associated with a higher risk of renal deterioration compared to selective renal angiography.*

Key Words: Renal; Artery; Angiography; Angioplasty; Renal deterioration; Risk factors.

Introduction

Hypertension and chronic renal failure due to renal artery stenosis (RAS) can be treated successfully by renal artery angioplasty on stenting.[1–9] However, many patients with RAS already have impaired renal function which may be calculated by renal angiography.[10–22]

Micro-embolisation into the kidney during the angioplasty has led some authors to recommend the use of endovascular protection devices.[23] However, the rate of renal impairment in patients undergoing selective renal artery angiography vs endovascular renal artery revascularisation has not been compared yet. The aim of the present study was to investigate how often renal function deteriorated in patients after angiography with and without subsequent angioplasty and to assess independent risk factors for the occurrence of renal function reduction.

Methods

All consecutive patients with renal artery stenosis who underwent selective renal artery angiography and who were planned for subsequent renal artery PTA from March 1, 1988 until September 31, 2000 at the Department of Angiology entered a retrospective survey. All patients in the intervention group and in the angiography group underwent selective renal angiography of both renal arteries. Patients who underwent overview angiography of the renal arteries during angiographic procedures in the abdominal aorta or in the lower limbs were excluded. The study was performed according to the Declaration of Helsinki.

Patients were identified by systematic chart review and review of the original angiography and PTA protocols. Following a strict protocol, angiography/PTRA were performed in patients with drug resistant arterial hypertension (more than 3 antihypertensive agents), pathological isotopic nephroscintigram and haemodynamically relevant renal artery stenosis documented by colour-coded duplexsonography

* Please address all correspondence to: E. Minar, University of Vienna, Department of Angiology, Vienna General Hospital, Währinger Gürtel 18–20, A-1090 Vienna, Austria.

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as well as in patients with suspicion of ischaemic nephropathy indicated by progressive reduction of renal function parameters in conjunction with stenotic flow pattern of the renal arteries in duplex sonography. The final indication for PTRA was a renal artery stenosis with more than 50% lumen narrowing. Stent implantation was performed in cases of residual stenosis >30% after primary dilatation or in cases of vessel dissection. Renal artery stenosis in vessels of shrunken kidneys were not eligible for PTRA. Shrunken kidneys was defined as reduced maximum diameter of at least 3 cm compared to the contralateral kidney. All angiographic procedures and interventions at our department are systematically recorded in an angiography/PTA registry. Findings of pre-interventional duplex sonography, angiographic data and PTA success were registered. Procedural complications and the post-procedural need for haemodialysis were documented routinely.

Hydration in patients with normal renal function was checked clinically by the physician in charge by aspects of the mucosa and skin. Patients with clinical suspicion of dehydration and patients with baseline serum creatinine levels $\geq 124\,\mu mol/l$ routinely received extra fluids intravenously peri-interventional as a protective strategy. Throughout the whole observation period the non-ionic, low-osmolality contrast agent Optiray 320, Tyco diluted to equal amount of physiological saline solution. Baseline serum creatinine, complete blood count and coagulation parameters were obtained in all patients before PTA. Serum creatinine was measured routinely 24 h after the intervention. In patients with an increase of serum creatinine of at least one third and in patients with a serum creatinine $\geq 124\,\mu mol/l$ at 24 h, creatinine values were obtained also at 48 h postintervention. All 85 patients had baseline and 24 h serum creatinine data available, in 27 patients (32%) serum creatinine was additionally measured 48 h after the intervention.

Pre-existent impaired renal function was defined as a serum creatinine $\geq 177\,\mu mol/l$ at admission.[24] Deterioration of renal function was defined as an increase of serum creatinine of at least one third from baseline within 24 h after the procedure.[17,29] Procedure complications were classified as either major complications (acute thrombotic renal artery occlusion after the procedure, major bleeding with a decrease of haemoglobin $> 20\,g/l$, persistent renal failure post-procedure and complications at the site of arterial puncture requiring surgical repair) or minor complications (dissection of the intima of the renal artery during PTA, mild and transient renal failure not requiring haemodialysis and local false aneurysms or haematoma at the site of arterial puncture, which were treated conservatively).

Statistical methods

Continuous data are presented as the median and the interquartile range (IQR, range from the 25th to the 75th percentile). Percentages were calculated for dichotomous data. The relative change of serum creatinine within 24 h post-procedure was calculated. Patients were then dichotomised according to a cut-off level of +1/3 of serum creatinine increase. The Chi-square test was applied to compare proportions. The Mann–Whitney *U*-test was used to compare continuous data. A multivariate logistic regression model was applied to assess independent predictors of renal function reduction and to adjust for confounding factors. Baseline variables that showed a trend towards a difference ($p < 0.2$) were entered into the model as possible confounding factors. The Hosmer Lemeshow test was used to assess the model fit. All *p*-values were calculated two-sided, a *p*-value < 0.05 was accepted as statistically significant. All calculations were performed with SPSS for Windows (Version 10.0, SPSS Inc., Chicago, Ill, U.S.A.).

Results

Eighty-five consecutive patients were included in the study. The median age was 65 years (IQR 54–74) and 49 patients were male (51%). Patients demographics and baseline data are given in Table 1.

Diagnostic bilateral renal angiography was performed in 53 (62%) patients and 32 (38%) had patients had balloon angioplasty – in half using a stent (Table 1). Intervention was performed immediately after angiography in 28 (88%) cases; in 4 during a second procedure. Two patients (4%) out of the PTRA group had an occluded contralateral renal artery, 2 patients (4%) showed a contralateral shrunken kidney and another 2 patients (4%) underwent contralateral nephrectomy earlier. Duration of the procedure and the amount of contrast agent is given in Table 1. Peri-procedural complications were observed in 9 patients (11%): 3 patients had persistent renal failure, 3 patients had a pseudo-aneurysm at the site of arterial puncture, 1 patient had an acute thrombotic renal artery occlusion, 1 patient suffered peri-interventional angina pectoris, and 1 patient had a vasovagal reaction with transient hypotension.

Baseline creatinine was $106\,\mu mol/l$ (IQR 87–136). Twenty-four hours after the procedure median

Table 1. Comparison of patients who had renal artery arteriography alone and patients who also had angioplasty. Median value (Interquartile range) and number (%) are given.

	Patients undergoing PTRA $n = 32$ (38%)	Patients undergoing Angiography $n = 53$ (62%)	p-value
Age	64 (54–75)	65 (54–74)	0.7
Male sex (%)	17 (20%)	29 (34%)	1.0
Body mass index kg/m^2	25 (23–28)	26 (23–28)	1.0
Diabetes mellitus* (%)	8 (9%)	17 (20%)	0.8
Current smokers (%)	11 (13%)	23 (27%)	0.7
Arterial hypertension (%)	27 (32%)	51 (60%)	0.4
Hyperlipidaemia* (%)	24 (28%)	47 (55%)	0.4
Cerebral artery disease (%)	21 (25%)	25 (29%)	0.05
Coronary heart disease (%)	12 (14%)	19 (22%)	0.7
Peripheral artery disease (%)	17 (20%)	36 (42%)	0.4
Pre-existing renal failure (%) (se-creatinine ≥ 177 µmol/l)	4 (5%)	4 (5%)	0.3
Creatinine serum level at baseline	1.3 (1.0–1.8)	1.1 (1.0–1.5)	0.1
Grade of stenosis in % luminal narrowing	80 (80–90)	30 (30–50)	<0.0001
PTA (%)	32 (100%)	0	–
Stent implantation	16 (50%)	0	–
Amount of contrast agent per ml	250 (198–280)	220 (141–270)	0.3
Duration of fluoroscopy min (IQR)	13 (9–22)	9 (3–14)	0.02
Renal function reduction (se-creatinine increase by >33%) within 24 h	5 (16%)	8 (15%)	0.9

* Diabetes mellitus: HbA1c level > 6.5%, pathological oral glucose tolerance tests or as fasting blood glucose values > 6.1 mmol/l measured 3 times. Hyperlipidaemia: total serum cholesterol levels > 5.4 mmol/l, serum low density lipoprotein > 3.4 mmol/l or serum triglycerides > 2.1 mmol/l after overnight fasting, and all patients receiving lipid lowering medication.

creatinine was 111 µmol/l (IQR 88–148) in the 85 patients. After 48 h, the serum creatinine level was available in 27 patients (32%) and was median 117 µmol/l (IQR 103–193). In 13 (15%) patients serum creatinine increased by $\geq 33\%$ within the first 24 h: 10 patients had a mild deterioration of renal function, and 3 patients developed persistent deterioration of renal function [(2/32 (6%) after PTRA/stenting and 1/53 (2%) after angiography]. All three patients had compromised renal function before the procedure, with pre-procedural creatinine levels of 203 µmol/l, 185 µmol/l and 433 µmol/l and two patients subsequently required haemodialysis.

Univariate comparison of patients with and without renal function reduction is presented in Table 2. Patients with renal function reduction were more frequently male, had pre-existent renal impaired, had a longer lasting fluoroscopy and received larger amounts of contrast agent. The rate of renal function reduction was equal in patients who had angiography alone and patients who had angioplasty in addition (Table 1).

A multivariate logistic regression model was applied to assess independent risk factors of renal function reduction and to adjust for confounding factors (Table 3). Pre-existent renal impairment and dosage of administered contrast agent were independent predictors of renal function reduction. Patients undergoing PTRA/stenting did not have an increased risk for renal function reduction compared to patients undergoing diagnostic selective renal artery angiography without intervention (Table 3).

Discussion

Pre-existent renal dysfunction and increasing amounts of contrast agent were independent risk factors for acute renal dysfunction in patients undergoing selective renal artery angiography or endovascular treatment of RAS.[25] Pre-existent moderate renal impairment was found in 13% in this patient series, but chronic deteriorated renal function was not present in any patient, since patients with irreversible reduction of renal function and shrunken kidney were not eligible for renal artery PTA.[26–32] At our department, the indication for PTA was set restrictively and revascularisation was only performed in patients with significant renovascular stenosis (>50%) presenting with severe hypertension (resistant to more than 3 antihypertensive drugs) and/or incipient and progressive renal dysfunction. This strategy is reflected in the low number of renal artery interventions performed at our institution during the study period. However, since endovascular treatment of patients with RAS and secondary hypertension by

Table 2. Univariate comparison of patients with or without acute renal function reduction (defined as an increase of serum creatinine of at least one third from baseline value within 24 h) after renal artery angiography and renal artery PTA. Median value (Interquartile range) and number (%) are given.

	Patients without renal function reduction $n = 72$ (85%)	Patients with renal function reduction $n = 13$ (15%)	p-value
Age	65 (55–73)	72 (54–76)	0.1
Male sex (%)	36 (49%)	11 (84 %)	0.03
Body mass index kg/m^2	25 (23–28)	27 (25–29)	0.2
Diabetes mellitus* (%)	17 (24%)	7 (54%)	0.4
Current smokers (%)	28 (39%)	3 (23%)	0.4
Arterial hypertension (%)	72 (100%)	13 (100%)	1.0
Hyperlipidaemia* (%)	60 (83%)	12 (92 %)	0.7
Carotid plaques/stenosis (%)	41 (57%)	7 (54%)	1.0
Coronary artery disease (%)	27 (38%)	4 (31%)	0.5
Peripheral artery disease (%)	49 (68%)	6 (46%)	0.2
Pre-existing renal failure (%) (se-creatinine ≥ 177 µmol/l)	6 (8%)	5 (39%)	0.01
Baseline serum creatinine µmol/l	106 (88–132)	115 (88–185)	0.2
PTA (%)	27 (38%)	5 (42%)	0.8
Stent implantation (%)	11 (22%)	5 (56%)	0.1
Amount of contrast agent per ml	220 (171–270)	280 (255–300)	0.008
Duration of fluoroscopy min	10 (5 to 14)	23 (8–24)	0.02
Dosage of heparin IU	5000	5000	0.8

* Diabetes mellitus: HbA1c level > 6.5%, pathological oral glucose tolerance tests or as fasting blood glucose values > 6.1 mmol/l measured 3 times. Hyperlipidaemia: total serum cholesterol levels > 5.4 mmol/l, serum low density lipoprotein > 3.4 mmol/l or serum triglycerides > 2.1 mmol/l after overnight fasting, and all patients receiving lipid lowering medication.

Table 3. Multivariate model of predictors for renal function reduction in patients undergoing renal artery angiography/PTA.

	Odds ratio	95% CI	p-value
Age ≥ 65 year ‡	5.0	0.6–62.0	0.2
Male sex	3.5	0.5–26.8	0.2
Diabetes mellitus	2.4	0.5–12.7	0.3
Pre-existing renal failure (%) (se-creatinine ≥ 177 µmol/l)	40.1	1.2–71.7	0.02
Amount of contrast agent ≥ 225 ml ‡	67.2	1.8–98.5	0.02
Duration of fluoroscopy ≥ 10 min ‡	1.9	0.2–15.9	0.6
Angioplasty ± stenting*	0.4	0.2–3.0	0.3

* Compared to selective renal angiography; ‡ Cut-off according to the median value.

angioplasty seems to have little advantage over antihypertensive drug therapy a rather conservative approach to renal revascularisation may be preferable.[32]

In our series, transient deterioration of renal function was found in 15% of patients. Application of contrast agent directly into the renal artery seems to result in increased nephrotoxicity, probably due to higher concentrations of contrast agent directly reaching the kidney.[18,33,34] However, angioplasty or stenting by themselves was not associated with an increased risk of renal deterioration. Although microembolism reportedly occurs during the angioplasty procedure,[23] these microemboli seem to be clinically well tolerated by a kidney with primarily normal function. However, there may be other explanations for our findings: On the one hand patients in the diagnostic angiographic group underwent selective angiography which is connected to renal artery catheterisation. This manipulation may also cause microembolism, although the extent of microembolism after angiography is expected to be lower compared to angioplasty. On the other hand, the measurement of the course of serum creatinine may not be sensitive enough to detect the effects of minimal embolism due to angioplasty. Renal function may significantly decrease with serum creatinine values remaining within the normal range. However, the course of serum creatinine is a practicable and clinically relevant study end point which also has been applied to patients with femoropopliteal PTA[18] as well as patients after cardiopulmonary resuscitation.[35] Furthermore, improvement of kidney perfusion after successful PTRA may protect and counteract against the injury inflicted by the use of contrast agent and catheter manipulation at the treated segment. In patients with pre-existing deterioration of renal function alternatively magnetic resonance imaging angiography[36] may be performed as the first diagnostic option for evaluation of RAS. Otherwise, when PTA is planned in cases with confirmed RAS, administration of contrast agent during angioplasty has to be kept to a minimum and the use of renal protection devices may be considered.

References

1 Olin JW, Piedemonte MR, Young JR *et al*. The utility of Duplex ultrasound scanning of the renal arteries for diagnosing significant renal artery stenosis. *Ann Intern Med* 1995; **122**: 833–838.
2 Sinclair AM, Isles CG, Brown I *et al*. Secondary hypertension in a blood pressure clinic. *Arch Intern Med* 1987; **147**: 1289–1293.
3 Danielson M, Dammstrom B-G. The prevalence of secondary and curable hypertension. *Acta Med Scand* 1981; **209**: 451–455.
4 Ballard JL. Renal artery endarterectomy for treatment of renovascular hypertension combined with infrarenal aortic reconstruction: analysis of surgical results. *Ann Vasc Surg* 2001; **15**(3): 260–266.
5 Hirning T, Gerlach A, Arlart IP. PTA of 131 renal artery stenoses: management of hypertension and organ support. *Rofo Fortschr Geb* 1993; **158**: 115–120.
6 Schwarten DE, Yune HY, Klatte EC, Grim CE, Weinberger MH. Clinical experience with percutaneous transluminal angioplasty of stenotic renal arteries. *Radiology* 1980; **135**: 601–604.
7 Greminger P, Steiner A, Schneider E *et al*. Cure and improvement of renovascular hypertension after percutaneous transluminal angioplasty of renal artery stenosis. *Nephron* 1989; **51**: 362–366.
8 Joffre F, Levade M, Sabatier JC *et al*. Treatment of renal artery stenosis by PTA. *J Radiol* 1980; **61**: 785–789.
9 Watson PS, Hadjipetrou P, Cox SV, Piemonte TC, Eisenhauer AC. Effect of renal artery stenting on renal function in patients with atherosclerotic renovascular disease. *Circulation* 2000; **102**: 1671–1677.
10 van Jaarsveld BC, Pieterman H, van Dijk LC *et al*. Interobserver variability in the angiographic assessment of renal artery stenosis. DRASTIC study group. Dutch Renal Artery Stenosis Intervention Cooperative. *J Hypertens* 1999; **17**: 1731–1736.
11 Hou SH, Bushinsky DA, Wish JB, Cohen JJ, Harrington JT. Hospital-acquired renal insufficiency: A prospective study. *Am J Med* 1983; **74**: 243–248.
12 Shusterman N, Strom BL, Murray TG *et al*. Risk factors and outcome of hospital-acquired acute renal failure: Clinical epidemiologic study. *Am J Med* 1987; **83**: 65–71.
13 Schwab SJ, Hlatky MA, Pieper KS *et al*. Contrast nephrotoxicity: A randomized controlled trial of a nonionic and an ionic radiographic contrast agent. *N Engl J Med* 1989; **320**: 149–153.
14 Parfrey PS, Griffiths SM, Barrett BJ *et al*. Contrast material-induced renal failure in patients with diabetes mellitus, renal insufficiency, or both. *N Engl J Med* 1989; **320**: 143–149.
15 Davidson CJ, Hlatky M, Morris KG *et al*. Cardiovascular and renal toxicity of a nonionic radiographic contrast agent after cardiac catherization: A prospective trial. *Ann Intern Med* 1989; **110**: 119–124.
16 Manske CL, Sprafka JM, Strony JT, Wang Y. Contrast nephropathy in azotemic diabetic patients undergoing coronary angiography. *Am J Med* 1990; **89**: 615–620.
17 Solomon R, Werner C, Mann D, D'Elia J, Silva P. Effects of saline, mannitol, and furosemide on acute decreases in renal function induced by radiocontrast agents. *N Engl J Med* 1994; **331**: 1416–1420.
18 Schillinger M, Haumer M, Mlekusch W *et al*. Predicting renal failure after peripheral percutaneous transluminal angioplasty in high risk patients. *J Endovasc Ther* 2001; **8**: 609–614.
19 Stevens MA, McCullough PA, Tobin KJ *et al*. A prospective randomized trial of prevention measures in patients at high risk for contrast nephropathy: results of the P.R.I.N.C.E. Study. Prevention of radiocontrast induced nephropathy clinical evaluation. *J Am Coll Cardiol* 1999; **33**: 403–411.
20 Tepel M, van der Giet M, Schwarzfeld C *et al*. Prevention of radiographic-contrast-agent-induced reductions in renal function by acetylcysteine. *N Engl J Med* 2000; **343**: 180–184.
21 Rich MW, Crecelius CA. Incidence, risk factors, and clinical course of acute renal insufficiency after cardiac catheterization in patients 70 years of age or older: a prospective study. *Arch Intern Med* 1990; **150**: 1237–1242.
22 Kapoor A, Sinha N, Sharma RK *et al*. Use of dopamine in prevention of contrast induced acute renal failure – a randomised study. *Int J Cardiol* 1996; **53**: 233–236.
23 Henry M, Klonaris C, Henry I *et al*. Protected renal stenting with the PercuSurge Guard Wire device. *J Endovasc Ther* 2001; **8**: 227–237.
24 Domanovits H, Müllner M, Sterz F *et al*. Impairment of renal function in patients resuscitated from cardiac arrest: frequency, determinants and impact on outcome. *Wien Klin Wochenschr* 2000; **112**: 161.
25 Airoldi F, Palatresi S, Marana I *et al*. Angioplasty of atherosclerotic and fibromuscular renal artery stenosis: Time, course and predicting factors of the effects in renal function. *Am J Hypertens* 2000; **13**: 1210–1217.
26 Zierler RE, Bergelin RO, Polissar NI *et al*. Carotid and lower extremity arterial disease in patients with renal artery atherosclerosis. *Arch Intern Med* 1998; **158**: 761–767.
27 Von Kemp K, van den Brande P, Peterson T *et al*. Screening for concomitant diseases in peripheral vascular patients. Results of a systematic approach. *Int Angiol* 1997; **16**: 114–122.
28 Wachtell K, Ibsen H, Olsen MH *et al*. Prevalence of renal artery stenosis in patients with peripheral artery disease and hypertension. *J Hum Hypertens* 1996; **10**: 83–85.
29 Missouris CG, Buckenham T, Cappuccio FP, MacGregor GA. Renal artery stenosis: a common and important problem in patients with peripheral vascular disease. *Am J Med* 1994; **96**: 10–14.
30 Rundback JH, Gray RJ, Rozenblit G *et al*. Renal artery stent placement for the management of ischemic nephropathy. *J Vasc Interv Radiol* 1998; **9**: 413–420.
31 Dorros G, Jaff M, Mathiak M *et al*. Four-year follow up of Palmaz – Schatz stent revascularization as treatment for atherosclerotic renal artery stenosis. *Circulation* 1998; **18**: 642–647.
32 Van Jaarsveld BC, Krijnen P, Pieterman H *et al*. The effect of balloon angioplasty on hypertension in atherosclerotic renal-artery stenosis.
33 Lautin EM, Freeman NJ, Schoenfeld AH *et al*. Radiocontrast-associated renal dysfunction: incidence and risk factors. *AJR Am J Roentgenol* 1991; **157**: 49–58.
34 Eisenberg RL, Bank WO, Hedgock MW. Renal failure after major angiography can be avoided with hydration. *AJR Am J Roentgenol* 1981; **136**: 859–861.
35 Domanovits H, Schillinger M, Mulliner M *et al*. Renal failure after cardiopulmonary resuscitation. *Intens Care Med* 2001; **27**(7): 11949.
36 Grenier N, Brichaux JC, Degreze P *et al*. Exploration of renal arteries by angio-MRI. *Ann Radiol* 1995; **38**: 69–78.

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